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## HOIST FOR AIRCRAFT CABIN CONSTRUCTION

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### FIELD OF THE INVENTION

This invention relates generally to hoists and, more specifically, to portable hoists.

### BACKGROUND OF THE INVENTION

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Hoists are used throughout manufacturing industries to lift assemblies or modules into place for installation. In particular, hoists are frequently used in aircraft manufacturing operations.

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For example, crew rest areas are included in commercial passenger and long haul cargo aircraft, such as the Boeing 777LR. Some of these crew rest areas are designed to be included in the crown of the fuselage, that is directly over the center seats. In order to accommodate the crew rest areas, wiring and ducting are moved outboard of the crown. Composite crew rest modules containing seats and bunks are suspended between specially engineered rails that also support stowbins located above seats in the cabin, as shown in FIGURE 1. Up to six modules, providing bunks and seats for up to twelve crew members, can be installed fore and aft in the fuselage crown.

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In a current fabrication/installation method, the crew rest modules are built as complete assemblies. The complete assemblies are then lifted into the crown of the airplane and secured in place. By installing complete modules with this method, flow time in the


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factory is conserved. Due to the large size and heavy weight of these modules, crew rest module installation requires a specific type of mechanical lift to correctly locate the modules in the crown of the fuselage. Space restrictions, portability, range of motion, and airplane floor loading concerns preclude the use of commercially available scissors lifts.

5        Shape, weight, and size of the crew rest modules preclude personnel from physically lifting the modules. The largest module is 84 inches wide, 56 inches tall, up to 113 inches long, and weighs over 600 lbs. Modules are typically loaded into the airplane sections prior to joining sections of the airplane. While moving the modules into the airplane, care must be taken not to load the airplane floor beyond 250 psi. A typical commercially available scissors  
10 lift capable of raising a module to the required waterline, about 97 inches off the floor, would weigh 1500 lbs. or more plus the weight of the module. A load weighing nearly one-ton would have to be maneuvered in the plane and the weight distributed across the floor.

      In addition, there is no known scissors lift configuration capable of handling the weight and reaching the required height that will collapse sufficiently while carrying a crew  
15 rest module to fit in the headroom available within the airplane fuselage

      Therefore, there currently exists an unmet need to safely and efficiently raise crew rest modules or other modules into place at the crown of an aircraft fuselage.

#### SUMMARY OF THE INVENTION

      The present invention provides a hoisting device that allows a module to be  
20 transported on a lightweight carriage capable of distributing the weight of the module across a floor, such as an airplane floor. The carriage is also capable of turning in its own footprint and moving in any direction. The carriage is capable of breaking down when empty and easily passes through a confined space, such as standard airplane passenger door, upon completion of use.

25        The hoisting device includes a frame that supports a module, and a lifting device that lifts the frame for properly placing the module. The lifting device includes a frame, attachment devices that attach the frame of the lifting device to overhead support frames, and a driving device that moves the frame of the lifting device up the attachment devices. The frame of the lifting device receives the frame that supports the module as the frame of the  
30 lifting device is moved by the driving device.

      In accordance with further aspects of the invention, the driving device includes gear boxes, a transfer tube mounted between two of the gear boxes for activating one of the two gear boxes when the other of the two gear boxes is activated, and two tubes coupled to two of the gear boxes. The tubes coupled to the two gear boxes rotate when one of the two gear  
35 boxes is activated. The tubes coupled to two of the gear boxes may be telescoping tubes.

In accordance with still further aspects of the invention, the attachment devices include two drums mounted to each of the tubes coupled to two of the gear boxes, and straps attached at a first end to each drum and at a second end to one of the overhead support frames. The drums receive the respective strap when the tubes are rotated by the respective gear box.

In accordance with still another aspect of the invention, the gear boxes include first and second gear boxes, and a bevel gear that is mechanically coupled to one of the first or second gear boxes. The transfer tube is mounted to one of the first or second gear boxes and the bevel gear. The transfer tube activates one of the first or second gear boxes when the bevel gear is activated.

In accordance with still further aspects of the invention, the first frame includes a support frame that supports the module and dollies that temporarily support the support frame. The support frame includes at least two telescoping frame members.

In accordance with yet another aspect of the invention, the support frame further includes mounting pads that support the module and saddles that rotatably receive the second frame as the second frame is lifted.

In accordance with further aspects of the invention, the attachment devices further include two or more rails attachable to the one or more overhead support frames and cars having wheels. Each car is coupled to a corresponding strap and the cars are slideably received by one of the rails.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

The preferred and alternative embodiments of the present invention are described in detail below with reference to the following drawings.

FIGURE 1 is a cross-sectional view of a crew rest area module mounted in a crown section of an aircraft fuselage;

FIGURES 2 and 3 are perspective views of a module lifting device formed in accordance with one embodiment of the present invention;

FIGURES 4A-D are perspective views of the module lifting device of FIGURES 2 and 3 in operation;

FIGURES 5-7 are perspective views of preferred embodiments of the present invention;

FIGURE 8 is a side view of an embodiment of a portion of the present invention; and

FIGURES 9 and 10 are perspective views of portions of an exemplary adjustment mechanism formed in accordance with the present invention.

## DETAILED DESCRIPTION OF THE INVENTION

Embodiments of the present invention provide lifting devices for mounting modules into a confined space, such as the crown section of airplanes. The lifting device may also be used in other environments where lifting or lowering of a heavy load into a tight location is necessary.

FIGURE 2 illustrates an exemplary lifting device 30 according to an embodiment of the present invention. The lifting device 30 includes a lifting unit 34 and a carriage unit 36. The lifting unit 34 includes two torque tubes 42 and 44 and strap drums 48-54 mounted to the torque tubes 42 and 44. The torque tubes 42 and 44 are linked by drive assemblies 60 and a transfer tube 66 mounted between the drive assemblies 60. The torque tubes 42 and 44 and the transfer tube 66 can be telescoping devices to allow the lifting unit 34 to be adjustable in width and length. The torque tubes 42 and 44 include internally mounted spring loaded stops to prevent the torque tubes 42 and 44 from accidentally pulling apart on extension.

The carriage unit 36 supports a module (not shown). The carriage unit 36 includes two dollies 76 and 78 and a support frame 86. Each of the dollies 76 and 78 include four wheels 80. The support frame 86 includes a rectangular frame having two opposing frame end members 93 and two opposing telescoping frame members 94 for accommodating various module lengths. Some embodiments may require that opposing frame end members 93 also be telescoping to accommodate varying widths as well. The dollies 76 and 78 receive the frame end members 93. The dollies 76 and 78 include flanges 95 that maintain the frame end members 93 in place on top of the dollies 76 and 78. Alternatively, locator pins or other means of position fixing may be used.

Support mounts 88 are attached near corners of the rectangular frame. The support mounts 88 include adjustable pads 90 for supporting the module (not shown). Four saddles 100 are mounted on the same side of the support frame 86 external to the location where the support mounts 88 mate with the frame 86. The saddles 100 extend below the frame 86 and restrict motion of the frame 86 on the respective dolly 76 and 78.

The straps 110 are secured at first ends to a respective strap drum 48-54. Second ends of the straps 110 are attached to portions of an overhead support device (not shown and described in more detail below). When a device (not shown) applies a gear driving force to one of the drive assemblies 60, the torque tubes 42 and 44 rotate to allow the strap drums 48-54 to rotate thereby winding-up the straps 110 and lifting the lifting unit 34. Lifting continues until the strap drums 48-51 are positioned within a corresponding pair of the saddles 100 and the torque tubes 42 and 44 are received by the saddles 100, thereby lifting the support frame 86 off of the dollies 76 and 78, as shown in FIGURE 3.

In one embodiment of the present invention, the straps 110 extend from the outside of each strap drum 48-54. The drum end of each strap 110 is suitably looped and sewn per loading specifications. The loop (not shown) in the drum end of each strap 110 is secured to the respective strap drum 48-54 via doubling over a steel pin (not shown). The doubled over portion of the strap end rests in a recess (not shown) machined within the drum 48-54. The recess insures that the strap will smoothly lay around the drum diameter. The strap drums 48-54 can receive about 100 in. of 1.75 in. wide strap. Straps of different widths, lengths, and load ratings can be accommodated by adjusting the strap drum dimensions.

FIGURES 4A-D illustrate an example sequence for lifting a module (a mockup of a module is shown) using the lifting device 30, as shown in FIGURES 2 and 3. Referring to FIGURE 4A, the lifting unit 34 is positioned on the deck of the aircraft relative to an overhead support device (not shown). The straps 110 are mounted to the overhead support device (not shown) at the location approximate to where the module is to be placed. The lifting device 30 is formed in a U-shape to receive the support frame 86 that is wheeled into place by the dollies 76 and 78. Referring to FIGURE 4B, the support frame 86 is moved within the lifting unit 34 until the straps 110 are received within a corresponding pair of saddles 100. A driving force is then applied to one of the drive assemblies 60, thus, rotating the torque tubes 42 and 44 and raising the lifting unit 34 until the lifting unit 34 is received by all of the saddles 100. The operator then checks each strap 110 for length and/or equal tension and makes adjustments via turnbuckles at the upper end of the straps to ensure that the lifting device 30 is level and is fully engaged in all the saddles before continuing with the application of the driving force. This sequence of events lifts the support frame 86 off of the dollies 76 and 78, as shown in FIGURES 4C and 4D.

FIGURES 5 and 6 illustrate an exemplary embodiment of a drive assembly 118. The drive assembly 118 includes two worm drive modules 124, a counter-rotating bevel gear box 120, and an extendable torque transfer tube 128. An example of the worm drive module 124 includes a worm drive gear such as that in a Varvel SRT 70-B849 worm drive unit, but other makes and models may be used including heavier duty units if required by the intended loads. One example of the bevel gearbox 120 is a Mitropak Model C-122-M gearbox with custom hex input shaft, but other makes and models could be used including heavier duty models if required by the intended loads. Keyed shafts (not shown) of both the worm drive module 124 and the bevel gearbox 120 are joined using a hollow coupler (not shown) with keyway. Other shaft coupling devices are possible with off-the-shelf parts. The choice of a coupling device is dependent upon the make and model of selected components as well as the size of the lifting device.

A nutrunner, air ratchet wrench or other similar rotary power tool (not shown) is attached to the bevel gearbox 120 hex input shaft for generating the necessary torque force to activate the lifting device 30. An air motor, electric motor, hydraulic motor, or other torque source may be incorporated into the drive assemblies 118 at the expense of added weight and complexity.

In one embodiment, the bevel gearbox 120 includes bevel gears that suitably provide a 2:1 reduction and the worm drive modules 124 provide a nominal 50:1 reduction for a total reduction ratio of 100:1. If the drive assemblies 118 are configured to handle up to a 600 RPM input, the output RPM at the torque tubes is approximately 4 to 5 RPM depending on the size of the load and the torque source. Other gear ratios are possible depending on the components selected.

FIGURE 6 illustrates an exemplary embodiment of a lifting unit. The strap drums 48-54 include a spool 130, roller flanges 132 located at the ends of the spool 130, and side flanges 134 located adjacent to the roller flanges 132. The spool 130 includes a square hole that receives a respective torque tube 42 and 44. The roller flanges 132, typically stainless steel (although other materials may be used) slide onto the respective torque tube 42 and 44 and are secured on either side of the spool 130 by the side flanges 134. The roller flanges 132 provide a bearing surface for the saddles 100, as shown in FIGURES 7 and 8. The side flanges 134 are aluminum, although other materials may be used. The side flanges 134 are secured to the spool 130 with shoulder style through bolts. The spools 130 are secured in position on the square torque tubes via dog point setscrews.

Because the strap drums 48-54 are mechanically linked, the most heavily loaded strap drum 48-54 controls the lifting speed, ensuring a level lift if set up was level at the lift start. If power is removed from the bevel gearbox 120, the worm drive module 124 resists overhauling and holds the load in place. The worm drive module 120 safely stops the lifting device 30.

Referring now to FIGURES 7 and 8, a side view of an exemplary saddle 100 is illustrated. The saddle 100 includes two housing sections 208 and two saddle sections 210. The saddle sections 210 are arched at their bases to form a groove 212 for receiving a torque tube 42 and 44. The edge of the saddle sections 210 includes ball bearing members or rotating wheels (i.e. cam followers) that protrude slightly into the groove 212 in order to provide a rolling surface that maintains contact with the respective torque tube 42 and 44. The cam followers roll on the roller flanges 132 while the torque tubes turn. Each of the housing sections 208 includes a spring device (not shown) that receives the saddle section 210. The spring device (not shown) allows the respective saddle section 210 to be

flexible with respect to the housing section 208. A crossbeam 214 is coupled between each of the housing sections 208 of the saddle 100. The housing sections 208 are attached to the support frame 86.

Referring now to FIGURES 9 and 10, one embodiment of an overhead support device 5 250 is shown. The overhead support device 250 mechanically couples the straps 110 to a frame 270 coupled to the fuselage. The overhead support device 250 includes four rail sections 256, four rail cars 258, and two rail car connectors 260. Each rail section 256 includes connecting devices 264 that attach to a support beam 270 mounted to the fuselage in order to structurally support stowage bins and crown modules. Each rail car 258 in the 10 embodiment shown is U-shaped with two vertical flanges 282 that rotatably receive the wheels 284. The wheels 284 are located on edges of the vertical flanges 282 that face each other. The wheels 284 are spaced apart by a pre-defined distance. The rail sections 256 are I-beams that are received between the wheels 284 of each rail car 258. Each rail car 258 hangs below the wheels 284 and thus below the rail section 256. The wheels 284 ride along a base 15 flange 290 of the rail section 256. An outboard end of the rail section 256 includes stoppers 292 mounted vertically on one of the lower flanges 290 or upper flanges 294 of the rail section 256 at a first end. The stoppers 292 prevent the rail car 258 from sliding off. Each rail section 256 may include a second end opposite the first end that also includes stoppers.

Extending from the rail cars 258 is a turnbuckle 300. Coupled to the turnbuckle 300 is 20 a device 308 that includes a horizontally supported pin 310. The strap 110 is looped around the pin 310 and sewn back onto itself.

Each rail car connectors 260 are attached to two rail cars 258, thereby making sure that when one of the rail cars 258 is moved the other rail car 258 attached to the other end of the rail car connectors 260 is moved. This allows for fine adjustment as to the longitudinal 25 location of the module when lifting it and putting it into place between the support beams 270.

The lifting device 30 allows a module to be lifted level and centered between the support beams 270. Because the lifting device 30 includes lifting straps 110 that are all mechanically linked, the lifting device 30 may be operated by a single installer who applies a 30 rotating tool to the gears (bevel gearbox 120 hex shaft input on the preferred embodiment).

In an alternate embodiment, a single worm gear powers two bevel gear sets that in turn rotate the torque tubes and consequently the strap drums. A passive brake system is desirable for use with the bevel gear sets.

While the preferred embodiment of the invention has been illustrated and described, 35 as noted above, many changes can be made without departing from the spirit and scope of the

invention. Accordingly, the scope of the invention is not limited by the disclosure of the preferred embodiment. Instead, the invention should be determined entirely by reference to the claims that follow.


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